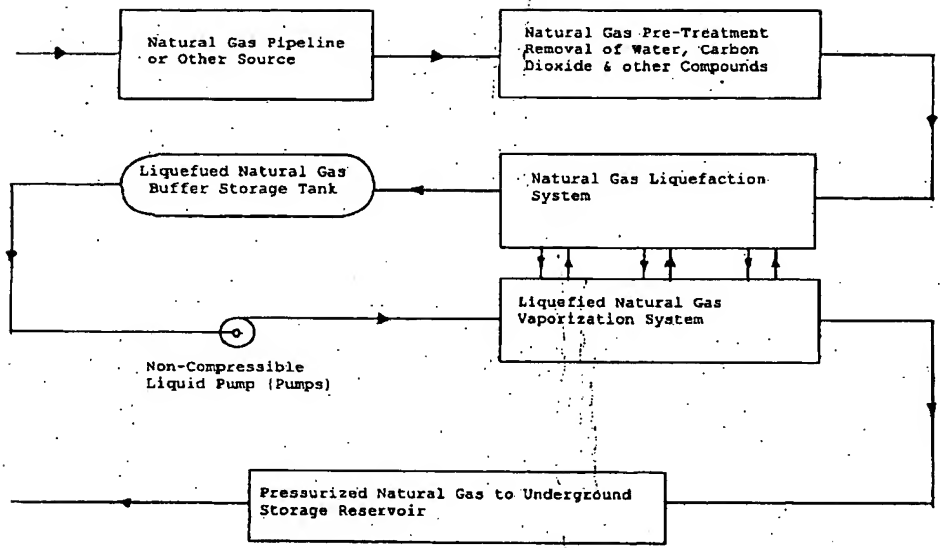
FIG. 1



This application is submitted in the name of inventor Conrad Q. Grenfell.

SPECIFICATION

METHOD AND APPARATUS FOR PRESSURIZING A GAS

BACKGROUND

A prior art method for charging or pressurizing of underground storage reservoirs with natural gas is to utilize a process system. In these types of systems, the natural gas from the source is processed to remove excess water and then compressed using mechanical compressors to the required underground storage pressure. Next, the system charges (or pressurizes) the underground reservoir with natural gas to the desired storage pressure. This technique is practiced in order to store natural gas in large quantities to provide for high demand, during peak periods of natural gas delivery to pipeline customers.

SUMMARY

The present application discloses a method and apparatus for pressurizing (or charging) natural gas into underground storage reservoirs. The method and apparatus utilizes a pipeline, or other natural gas source, with a thermodynamic near-cryogenic or cryogenic refrigeration liquefaction process system, an in-compressible pumping system, and gas re-vaporization system, as described herein, to charge underground storage reservoir facilities with natural gas at moderate, to high, pressure.

BRIEF DESCRIPTION OF THE FIGURE

Referring now to the figure:

FIG. 1 is a block diagram of the near-cryogenic or cryogenic liquefied natural gas system.

BRIEF DESCRIPTION

The method and apparatus described herein provides a more economical process of providing the moderate to high pressure necessary for charging or pressurizing, natural gas into underground storage reservoirs.

The present invention includes utilizing a method of liquefying natural gas, and then pumping the liquefied natural gas, as a near-cryogenic or cryogenic non-compressible fluid, to attain the pressure necessary for underground storage of the natural gas. Pumping of the non-compressible near cryogenic or cryogenic liquefied natural gas requires significantly less energy than does the prior art practices of compressing the natural gas using mechanical compressors.

Thermal energy can be recovered from the liquefied natural gas after the pumping process, in which the near cryogenic or cryogenic liquefied natural gas is vaporized into processed natural gas for storage, and at the same time cools the unprocessed natural gas by heat exchange as it enters the process system. Re-vaporization of the liquefied natural gas to a gaseous state is required for charging the underground reservoir in order to store the natural gas. The liquefied natural gas re-vaporization provides refrigeration energy to the liquefaction process, thereby reducing the total amount of energy required for liquefaction of the natural gas. Liquefaction of the natural gas stream is necessary for pumping the liquefied natural gas at a near-cryogenic or cryogenic non-compressible fluid (or liquid).

The present application is further described as a non-compressible near-cryogenic or cryogenic liquefied natural gas system for pressurizing (charging) underground natural gas storage reservoirs, processing the natural gas from a pipeline (or other natural source) as follows:

Unprocessed natural gas is provided to the near-cryogenic or cryogenic liquefied natural gas system from the pipeline source at a nominal pipeline transmission pressure, (approximately 500 to 1200 psig) and at ambient temperature. The near-cryogenic or cryogenic liquefied natural gas system removes the excess water and compounds, as necessary for the liquefaction of the natural gas stream. The near-cryogenic or cryogenic

liquefied natural gas system liquefaction process utilizes thermo-refrigeration process systems, such as a propane, ethylene, and methane cascade refrigeration process or a mixed refrigerant type process system or some combination thereof, in order to achieve the near-cryogenic or cryogenic liquefaction of the natural gas. Further, the near-cryogenic or cryogenic liquefied natural gas system may embody a gas or liquid expansion device, such as a Turbo-Expander, to provide additional refrigeration effect to the unprocessed natural gas stream.

After the unprocessed natural gas has been liquefied into liquefied natural gas, it is then pumped up to the required underground storage pressure (i.e., about 2,000 psig) using a centrifugal and/or positive displacement type pump (or pumps). The liquefied natural gas stream may incorporate a storage tank into the system upstream of the pump to provide for liquid surge and proper pump operation.

The liquefied natural gas that has been pumped to the required underground storage reservoir pressure is then returned to the liquid natural gas liquefaction system for vaporization by conversion of near-cryogenic or cryogenic liquid natural gas fluid to a gaseous state. This conversion from a liquid to gaseous phase, recovers significant refrigeration energy back to the near-cryogenic or cryogenic liquefied natural gas system for further economic savings.

The liquefied natural gas re-vaporization process provides refrigeration energy to pre-cool the unprocessed natural gas entering the near-cryogenic or cryogenic liquefied natural gas system and/or to provide refrigeration energy to the cascade (or mixed) refrigerant system for reduction of total energy required for liquefied natural gas liquefaction in the near-cryogenic or cryogenic liquefied natural gas system. In addition, the re-vaporization process provides refrigeration energy to the liquefied natural gas liquefaction process and is also used to cool the unprocessed natural gas entering the system for removal of the excess water, carbon dioxide, and other compounds, prior to entering the near-cryogenic or cryogenic liquefaction process.

The vaporized processed natural gas leaving the system is at or near ambient temperature and at the required underground storage reservoir pressure (about 2,000

psig). The vaporized processed natural gas is piped to the underground storage reservoir. The near-cryogenic or cryogenic liquefied natural gas process of the present application is more cost effective for pipeline customers, utilities, and natural gas consumers than the prior art processes.

The method and apparatus of the present application is not limited to use with only natural gas or to end to gas storage. Other uses are contemplated including pressurizing other useful gases, including but not limited to ethylene and methane.

While embodiments and applications of this invention have been shown and described, it would be apparent to those skilled in the art that many more modifications than mentioned above are possible without departing from the inventive concepts herein. The invention, therefore, is not to be restricted to the appended claims.

What is claimed is:

CLAIMS

1. A method of pressurizing gas comprising:

providing a stream of unprocessed natural gas;

pretreating said unprocessed natural gas;

processing said unprocessed natural gas into a liquefied natural gas in a liquefication system;

directing said liquefied natural gas to a storage tank via at least one non-compressible pump;

directing said liquefied natural gas with said at least one non-compressible pump to a vaporization system for conversion to a processed natural gas;

pressurizing said processed natural gas; and

directing said processed natural gas to an underground storage reservoir.